Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/14**

Paper 1 Multiple Choice **May/June 2025**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS

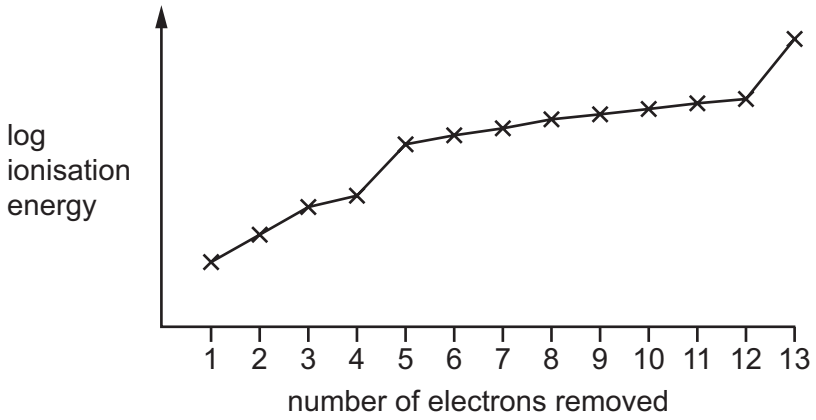
- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has **20** pages. Any blank pages are indicated.

1 The diagram shows the logarithm of the first 13 ionisation energies of an element.



Which statement is correct?

A A proton is lost for each successive ionisation energy.

B The element is aluminium.

C The element is silicon.

D The element has only one outer electron.

2 What is the empirical formula of butanoic acid?

A C_2H_4O **B** C_3H_6O **C** C_4H_8O **D** $C_5H_{10}O$

3 In which pair is the bond angle in the first species smaller than the smallest bond angle in the second species?

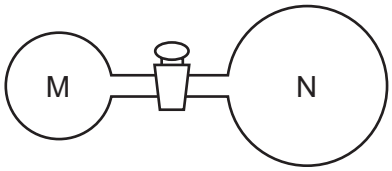
A CH_4 and SF_6

B CO_2 and BF_3

C H_2O and H_3O^+

D NH_4^+ and NH_3

4 Two glass vessels, M and N, are connected by a closed valve.



M contains helium at 20 °C at a pressure of 1×10^5 Pa. N has been evacuated, and has three times the volume of M.

The valve is opened and the temperature of the whole apparatus is raised to 100 °C.

What is the final pressure in the system?

A 3.18×10^4 Pa

B 4.24×10^4 Pa

C 1.25×10^5 Pa

D 5.09×10^5 Pa

5 Solid sulfur consists of molecules made up of eight atoms covalently bonded together.

The bonding in sulfur dioxide is O=S=O.

enthalpy change of combustion of S_8, $\Delta H_c^{\ominus} S_8(s) = -2376\,kJ\,mol^{-1}$

energy required to break 1.0 mol $S_8(s)$ into gaseous atoms = $2232\,kJ\,mol^{-1}$

O=O bond enthalpy = $496\,kJ\,mol^{-1}$

Using these data, what is the value of the S=O bond enthalpy?

A $239\,kJ\,mol^{-1}$ **B** $257\,kJ\,mol^{-1}$ **C** $319\,kJ\,mol^{-1}$ **D** $536\,kJ\,mol^{-1}$

6 In this question, the average oxidation state of sulfur in $\underline{S}_2O_3^{2-}$ and sulfur in $\underline{S}_2O_4^{2-}$ should be used.

In which reaction does the underlined element have the largest increase in oxidation state?

A $3\underline{Cr}O_4^{3-}(aq) + 8H^+(aq) \rightarrow 2CrO_4^{2-}(aq) + Cr^{3+}(aq) + 4H_2O(l)$

B $2\underline{N}O_2(g) + H_2O(l) \rightarrow HNO_3(aq) + HNO_2(aq)$

C $\underline{S}_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S(s) + SO_2(g) + H_2O(l)$

D $2\underline{S}_2O_4^{2-}(aq) + H_2O(l) \rightarrow S_2O_3^{2-}(aq) + 2HSO_3^-(aq)$

7 Methanol, CH_3OH, is made industrially from carbon monoxide and hydrogen in the equilibrium reaction shown.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -100\,kJ\,mol^{-1}$$

Which statement about this equilibrium is correct?

A K_p for the process is $\dfrac{p_{CH_3OH}}{p_{CO} \times p_{H_2}}$.

B An increase in pressure increases the equilibrium yield of methanol.

C An increase in temperature increases the equilibrium yield of methanol.

D The addition of an effective catalyst increases the equilibrium yield of methanol.

8 The distribution of molecular energies in an ideal gas can be represented in a Boltzmann distribution.

Which change in conditions leads to a **larger** value for the number of molecules that have the most probable energy?

A keeping the temperature constant but decreasing the pressure

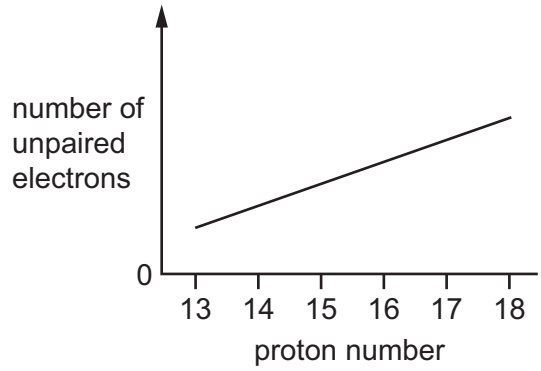
B keeping the pressure constant but decreasing the temperature

C keeping the temperature constant but increasing the pressure

D keeping the pressure constant but increasing the temperature

9 Which graph represents the number of unpaired electrons in the atoms of six elements in Period 3 of the Periodic Table?

A



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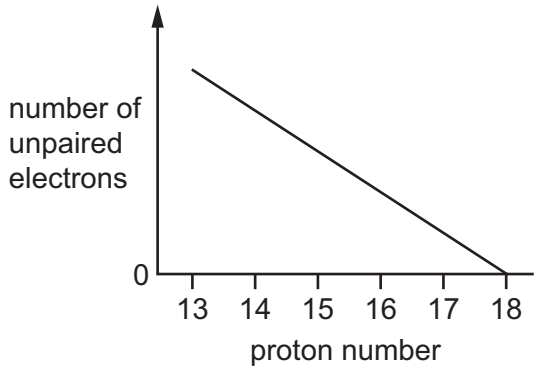

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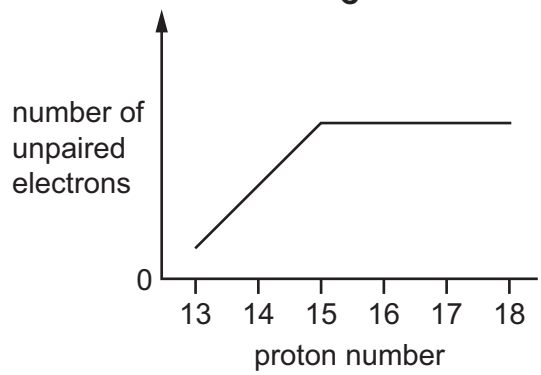

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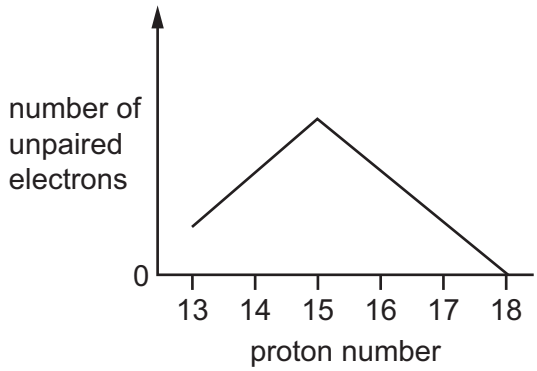


10 A 69.0 g sample of nitrogen dioxide is placed in a reaction vessel.

The initial pressure of the nitrogen dioxide is *P*. An effective catalyst is then added and the nitrogen dioxide begins to decompose into its elements.

After ten minutes, the total pressure is 1.1*P*.

What is the mass of oxygen molecules in the reaction vessel after ten minutes?

A 4.80 g **B** 9.60 g **C** 38.4 g **D** 48.0 g

11 Which statement about the molecule PF_5 is correct?

A Every F–P–F bond angle is 90°.

B The central atom in the molecule does **not** have a lone pair of electrons.

C The molecule has an overall dipole moment.

D The shape of the molecule is octahedral.

12 Which solid compound has both ionic and covalent bonding but **not** coordinate bonding?

A Al_2Cl_6 **B** CH_3COONa **C** $MgCl_2$ **D** NH_4Cl

13 Which equation represents the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, for ethanol?

A $2C(s) + 2\frac{1}{2}H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(g)$

B $2C(s) + 2\frac{1}{2}H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$

C $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(g)$

D $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$

14 When K_2MnO_4 reacts with concentrated hydrochloric acid, the products include chlorine molecules and $MnCl_2$. All of the manganese atoms are reduced to $MnCl_2$.

Both Mn and Cl change their oxidation numbers during the reaction. No other element is oxidised or reduced.

Using these changes in oxidation number, how many moles of chlorine will be produced when 1.0 mol of K_2MnO_4 reacts with an excess of hydrochloric acid?

A 2.0 mol **B** 2.5 mol **C** 3.0 mol **D** 4.0 mol

15 A nitrogen–hydrogen mixture, initially in the mole ratio of 1 : 3, reaches equilibrium with ammonia when 50% of the nitrogen has reacted. The total final pressure is *p*.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

What is the partial pressure of ammonia in the equilibrium mixture?

A $\frac{p}{6}$ **B** $\frac{p}{4}$ **C** $\frac{p}{3}$ **D** $\frac{p}{2}$

16 Propyl methanoate is hydrolysed with NaOH(aq) at 20 °C to form two products, X and Y. Product X is an alcohol.

Data from the experiment is shown.

time / s	[X] / mol dm^{-3}
0	0.000
40	0.004
80	0.007
120	0.010
180	0.015
240	0.019
300	0.022

Which row is correct?

	average rate of reaction between 240 and 300 s	product Y
A	5.00×10^{-5} mol dm^{-3} s^{-1}	HCOONa
B	5.00×10^{-5} mol dm^{-3} s^{-1}	HCOOH
C	7.33×10^{-5} mol dm^{-3} s^{-1}	HCOONa
D	7.33×10^{-5} mol dm^{-3} s^{-1}	HCOOH

[Turn over

17 The table shows the numbers of bond pairs and lone pairs in four different species.

Which row is correct?

	species	total number of bond pairs	total number of lone pairs
A	nitrogen molecule	3	1
B	ammonia molecule	4	1
C	ammonium ion	4	0
D	hydroxide ion	1	4

18 Which row is correct?

	property	explanation
A	AgI dissolves in aqueous ammonia more readily than AgCl does	AgI reacts with aqueous ammonia
B	HCl decomposes more readily than HI does	Cl is more electronegative than I
C	I_2 has a higher melting point than Cl_2	I_2 has stronger van der Waals' forces than Cl_2
D	I_2 is a stronger oxidising agent than Cl_2	an I atom loses electrons more readily than a Cl atom

19 Substance J reacts with water. A gas is given off and the pH of the solution increases. The solution is then reacted with sulfuric acid and a white precipitate forms.

What could be substance J?

A barium

B barium oxide

C magnesium

D magnesium oxide

20 Compound L has empirical formula NH. It decomposes on gentle heating to produce ammonia and compound M only. An aqueous solution of compound L is a good conductor of electricity.

Which row could be correct?

	identity of M	species present in L(aq)
A	N_2H_4	N^{3-} and H^+
B	N_2H_4	NH_4^+ and NH_2^-
C	HN_3	NH_3 and HN_3
D	HN_3	NH_4^+ and N_3^-

21 X, Y and Z are elements in Period 3 of the Periodic Table. The results of some experiments carried out with compounds of these elements are shown.

element	result of adding the oxide of the element to H_2O(l)	result of adding the chloride of the element to H_2O(l)	result of adding the oxide of the element to HCl(aq)
X	no reaction	hydrolyses	forms chloride salt
Y	forms hydroxide	dissolves	forms chloride salt
Z	forms acid	hydrolyses	hydrolyses

Which statement is correct?

A Element X is Al and element Y is Mg.

B Element X is Si and element Y is Na.

C Element Y is Al and element Z is P.

D Element Y is Na and element Z is Al.

22 The flow diagram shows two successive reactions starting from element Q. Element Q is either calcium or barium.

element Q —(1: heat with oxygen)→ —(2: add to water)→ compound R

Element Q forms a nitrate that is less thermally stable than strontium nitrate.

What is the identity of compound R?

A CaO **B** $Ca(OH)_2$ **C** BaO **D** $Ba(OH)_2$

23 Which anions are formed when chlorine is passed into cold aqueous potassium hydroxide?

A Cl^- and ClO^-

B Cl^- and ClO_3^-

C Cl^- and ClO_4^-

D ClO^- and ClO_3^-

24 What increases for each successive element in Period 3 from sodium to sulfur?

A the highest oxidation number of the element seen in an oxide

B the melting point of the elements

C the number of occupied orbitals in the atom

D the pH of the solutions of the chlorides in water

25 Which statement about an ammonium ion is correct?

A All of the H–N–H bond angles in the ion are 90°.

B All of the H–N–H bond angles in the ion are 107°.

C The ion contains a N–H dative covalent bond which is weaker than the other three N–H covalent bonds.

D The ion will react with a base as it is a weak acid.

26 An alcohol, U, is reacted with hot acidified $K_2Cr_2O_7$ solution. The organic product of the reaction contains 58.8% C, 9.8% H and 31.4% O by mass.

What is the identity of alcohol U?

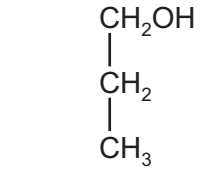
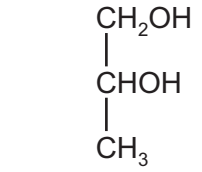
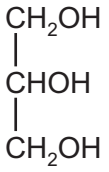
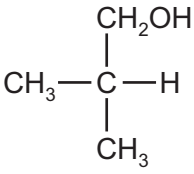
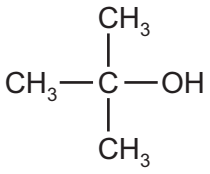
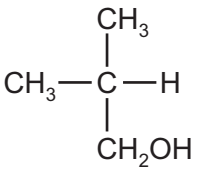
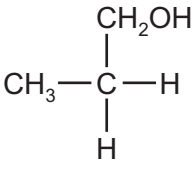
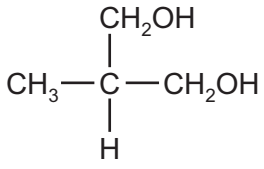
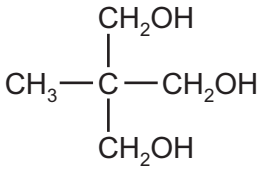
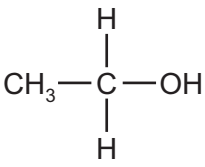
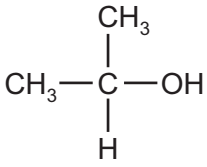
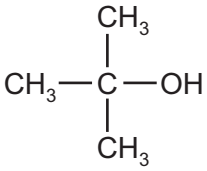
A 2-methylbutan-2-ol

B 3-methylbutan-2-ol

C pentan-1-ol

D propan-1-ol

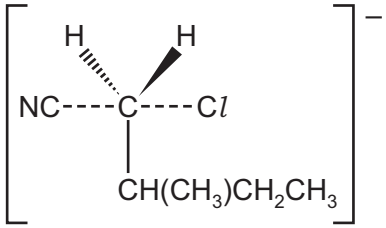
27 Which row shows a primary, a secondary and a tertiary alcohol?

	primary	secondary	tertiary
A			
B			
C			
D			

28 1-chloro-2-methylbutane reacts with sodium cyanide in a nucleophilic substitution reaction.

What is the most likely intermediate or transition state in this reaction?

A



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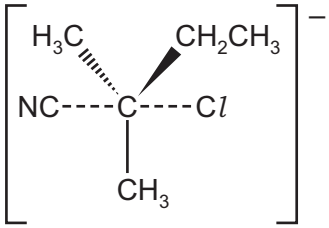

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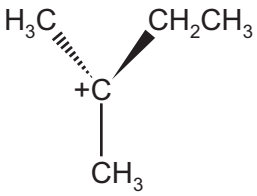

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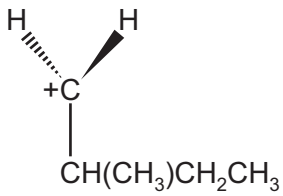
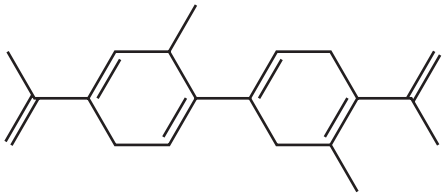


29 When 0.010 mol of a hydrocarbon X reacts with 720 cm^3 of hydrogen at room conditions, an alkane is formed.

What is hydrocarbon X?

A



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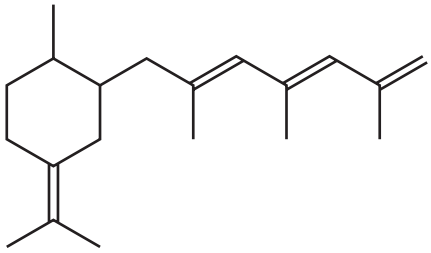

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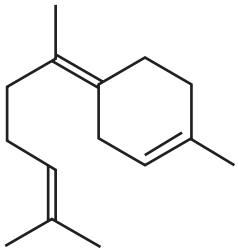

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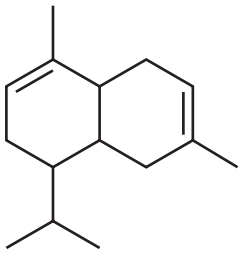
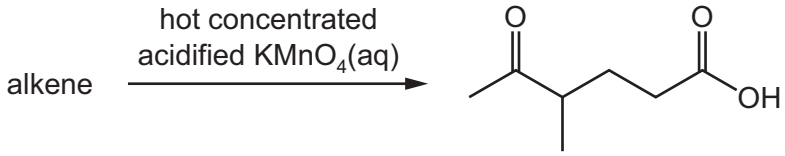
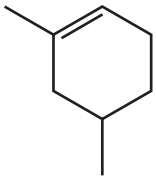


30 An alkene reacts with hot concentrated acidified $KMnO_4$ to produce a single organic product as shown.



What is the structure of the alkene?

A



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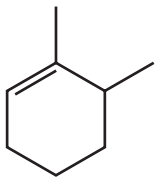

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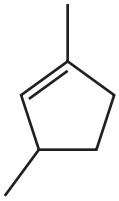

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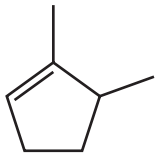
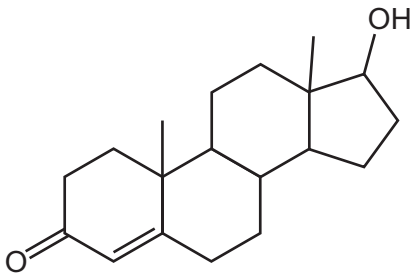


31 Testosterone is an optically active organic molecule.

testosterone



How many chiral centres are there in one molecule of testosterone?

A 5 **B** 6 **C** 7 **D** 8

32 Quinone is an unsaturated molecule.

quinone

Which statement about quinone is correct?

A Quinone is non-planar and has an overall dipole moment.

B Quinone is non-planar and does **not** have an overall dipole moment.

C Quinone is planar and has an overall dipole moment.

D Quinone is planar and does **not** have an overall dipole moment.

33 Which reagent would react with 1-bromopropane to give the highest yield of propene?

A ammonia

B aqueous potassium hydroxide

C potassium cyanide

D ethanolic sodium hydroxide

34 Acidified potassium dichromate(VI), $K_2Cr_2O_7$, is added to propan-1-ol and the mixture is immediately distilled. The distillate is treated with HCN in the presence of KCN.

What is the organic product?

A $CH_3C(CN)(OH)CH_3$

B $CH_3CH_2CH_2CO_2H$

C $CH_3CH_2CH(OH)CN$

D $CH_3CH_2CH_2CN$

35 Compound Q gives positive results when tested separately with alkaline I_2(aq) and with Tollens' reagent.

What is compound Q?

A $CHOCH_2CH_2CHO$

B CH_3CH_2COCHO

C CH_3COCH_2CHO

D $CH_3COCOCH_3$

36 Structural isomerism and stereoisomerism should be considered when answering this question.

How many isomeric esters of methanoic acid can be made with the molecular formula $C_5H_{10}O_2$?

A 2 **B** 3 **C** 4 **D** 5

37 The juice of one lemon reacts completely with 120 cm^3 of 0.50 mol dm^{-3} sodium carbonate solution.

The formula of citric acid is $HOOCCH_2C(OH)(COOH)CH_2COOH$.

No sodium carbonate is left unreacted.

What is the amount of citric acid in one lemon assuming that it is the only acid in the sample?

A 0.02 mol **B** 0.04 mol **C** 0.06 mol **D** 0.09 mol

38 Separate samples of 1-bromopropane are used in two different reactions.

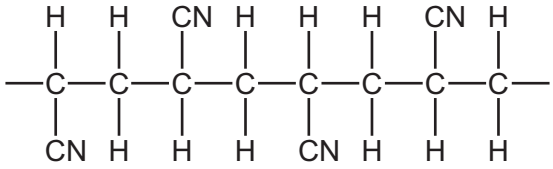
reaction 1 1-bromopropane is converted into compound X by heating it under pressure with ammonia in ethanol.

reaction 2 1-bromopropane is converted into compound Y. Compound Y undergoes hydrolysis to form butanoic acid.

Which row identifies compound X and describes the reagents used in reaction 2 to make compound Y?

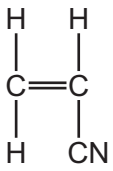
	identity of compound X	reagents for reaction 2
A	$CH_3CH_2CH_2NH_2$	HCN(aq)
B	$CH_3CH_2CH_2NH_2$	KCN dissolved in ethanol
C	$CH_3CH_2CH_2OH$	HCN(aq)
D	$CH_3CH_2CH_2OH$	KCN dissolved in ethanol

39 The diagram shows part of a polymer chain.

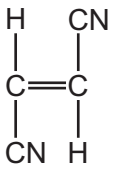


Which monomer would form this polymer?

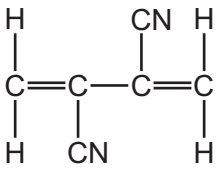
A



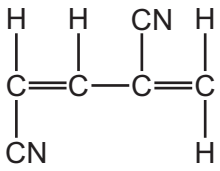
B



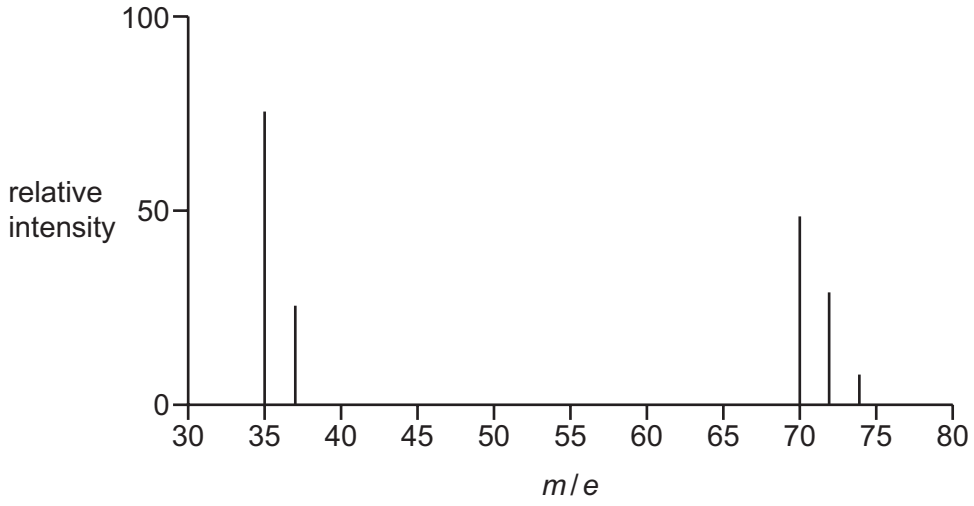
C



D



40 The mass spectrum of element Z is shown.



What is element Z?

A arsenic

B chlorine

C gallium

D tungsten

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Important values, constants and standards

molar gas constant	$R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\,\text{C mol}^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23}\,\text{mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,\text{C}$
molar volume of gas	$V_m = 22.4\,\text{dm}^3\,\text{mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,\text{dm}^3\,\text{mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,\text{mol}^2\,\text{dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –